

APPENDIX D

METHODS FOR CONTROLLING RESPIRABLE COAL MINE DUST FROM OVERBURDEN DRILLING AT SURFACE COAL MINES

This appendix focuses on methods of reducing excess respirable dust exposures during overburden drilling, the activity that places surface coal miners at the greatest risk of exposure to respirable crystalline silica.

D.1 ENGINEERING CONTROLS

Engineering controls for overburden drilling include dry dust collection systems, wet dust suppression systems, and enclosed cabs [Zimmer and Lueck 1986; Volkwein et al. 1979]. Proper maintenance of the dust suppression system is critically important for drills using dry dust suppression methods. Failure to rigorously maintain these systems will result in inadequate dust control. Acute silicosis has been reported in miners operating equipment that relies on dry dust suppression [NIOSH 1992].

D.1.1 Dry Dust Collection Systems

Dry dust collection systems typically include a drill platform shroud, a drill stem seal, and a dust collector.

D.1.1.1 Drill Platform Shroud

A drill platform shroud is essentially a skirt made of a flexible material (usually rubber) that hangs from the underside of the drill platform and surrounds the drill hole. The shroud enclosure, which is maintained under negative pressure, contains the dust that comes out of the drill hole. When the system is equipped with an adjustable shroud, the shroud height (the distance between the ground and the bottom of the shroud) should be kept as low as possible. A BOM [Zimmer and Lueck 1986] study found that although results differ with various drills, the control efficiency generally decreases as the shroud height increases. The same study reported that for the two drills tested, control efficiencies varied from 99% to 41% over the 0- to 27-in. height range and the collection system performed most efficiently when the shroud height was no greater than 9 in. In practice, however, maintaining a consistent height around the shroud because of uneven ground surfaces is not always possible.

D.1.1.2 Drill Stem Seal

The point at which the drill stem passes through the drill platform can be a source of dust emission. To control this dust source, a flexible collar that acts like a seal is placed around the drill stem at the platform level. The integrity of the seal must be maintained to prevent dust leakage.

D.1.1.3 Dust Collector

The dust from the shroud enclosure is transported through a duct to a collection chamber containing paper or fabric filters. An exhaust fan located on the clean side of the filters maintains a negative pressure inside the duct and the shroud enclosure and draws the dust-laden air through the filters at rates greater than 4 to 6 times the bailing airflow and varying from 600 to 6,000 cfm, depending on the size of the system. The filtered air is exhausted to the atmosphere and the dust is trapped on the filters. The filters are periodically cleaned with a reverse pulse of compressed air, which sends the collected dust into a hopper for discharge onto the ground away from the drill crew.

Test data have shown that dry dust collection systems are capable of achieving greater than 95% control efficiency [Zimmer and Lueck 1986], but this control efficiency may not always be reproducible in practice. Table D-1 summarizes the advantages and disadvantages of dry dust collection systems.

D.1.2 Wet Dust Suppression Systems

In wet dust suppression systems, water is pumped from a storage tank into a line injecting the bail air into the interior of the drill stem. The water droplets in the bail air coat and aggregate the dust as they are carried upward through the drill hole. Thus, the dust is suppressed by the weight of the moisture as the air bails out the cuttings from the hole. Because the water is expended in the process, the storage tank may have to be refilled one or more times per day. Normally, the water has to be transported to the drilling site.

The effectiveness of the control also depends on the experience and skill of the driller, who controls the flow rate manually with a control valve. The driller often must adjust the flow rate based on his visual estimation of the moisture content of the cuttings. Excessive water in the bail air would make the cuttings too heavy to be bailed up the drill hole. Also, cuttings with excessive moisture would plug up the air orifices of the drill bit. The flow-efficiency relationship may have to be determined more than once in a particular mine because it is affected by different drills, different bit sizes, or different types of geologic strata. A flowmeter should be installed at the control valve to aid this determination [Zimmer and Lueck 1986].

In one study [Zimmer and Lueck 1986], for example, control efficiencies for a selected drill varied from 9% at a water flow rate of 0.2 gallon per minute (gpm) to 96% at 1.2 gpm; the greatest increase in control efficiency was in the range of 0.4 to 0.6 gpm. These figures are valid only for the conditions under which the tests were conducted.

Table D-1. Advantages and disadvantages of dry dust collection systems*

Advantages	Disadvantages
Operate at any outside temperature	Expensive to install
Do not require any expendable material (water)	Expensive to maintain
Function well when properly maintained and operated	Require conscious effort by driller to ensure efficiency
	May not be suitable where ground water or coal-bed fires are present

* Adapted from Zimmer and Lueck [1986].

Bit life can be shortened by 50% or more because of the degrading effects of excessive moisture on the bit [BOM 1988]. When outdoor temperatures drop below the freezing point, the system must be heated to alleviate operational problems. Antifreeze compounds may be added to the water to prevent freezing, but this method could be extremely expensive when large volumes of water are used.

The control efficiency of wet dust suppression is similar to that of dry dust collection [Zimmer and Lueck 1986]. Table D-2 summarizes the advantages and disadvantages of wet dust suppression systems. Figure D-1 illustrates a wet dust suppression system.

D.1.3 Enclosed Cab

Drills come in different sizes. Depending on the size, the drills may or may not be equipped with cabs, and the cabs may be partially or totally enclosed. When a totally enclosed cab is available, an effective way to protect the driller working inside the cab is to pressurize it (positive pressure relative to the outside) with outside air drawn through an air filter capable of removing respirable dust. A NIOSH health hazard evaluation [Cornwell and Hanke 1983] reported that the use of a pressurized cab alone (without dry dust collection or wet dust suppression) could afford a respirable dust concentration that was 70% lower than that outside the cab. Subsequent information [Cornwell 1990] revealed that the air filter used for the cab was graded as 99.9% efficient in removing fine test dust as defined by the Society of Automotive Engineers [SAE 1987]. Thus, the control efficiency may be highly dependent on the grade of the air filter.

Air conditioning should be installed in the cab to eliminate the need for opening the cab door or windows in hot weather. When the cab door or windows are open, even the best dust filtration system will not be effective. The air conditioning unit needs to be rugged in construction. Ordinary automotive air-conditioning units are not able to withstand the severe conditions found in the mining

Table D-2. Advantages and disadvantages of wet dust suppression systems*

Advantages	Disadvantages
Inexpensive to install	Must be heated in cold temperatures or used with antifreezing additive
Inexpensive to maintain	Require some expertise on behalf of drill operator for proper operation
Function well when properly operated	Require use of expendable material (water)
Not affected by groundwater or bed fires	May cause decreased bit life and drilling efficiency

*Adapted from Zimmer and Lueck [1986].

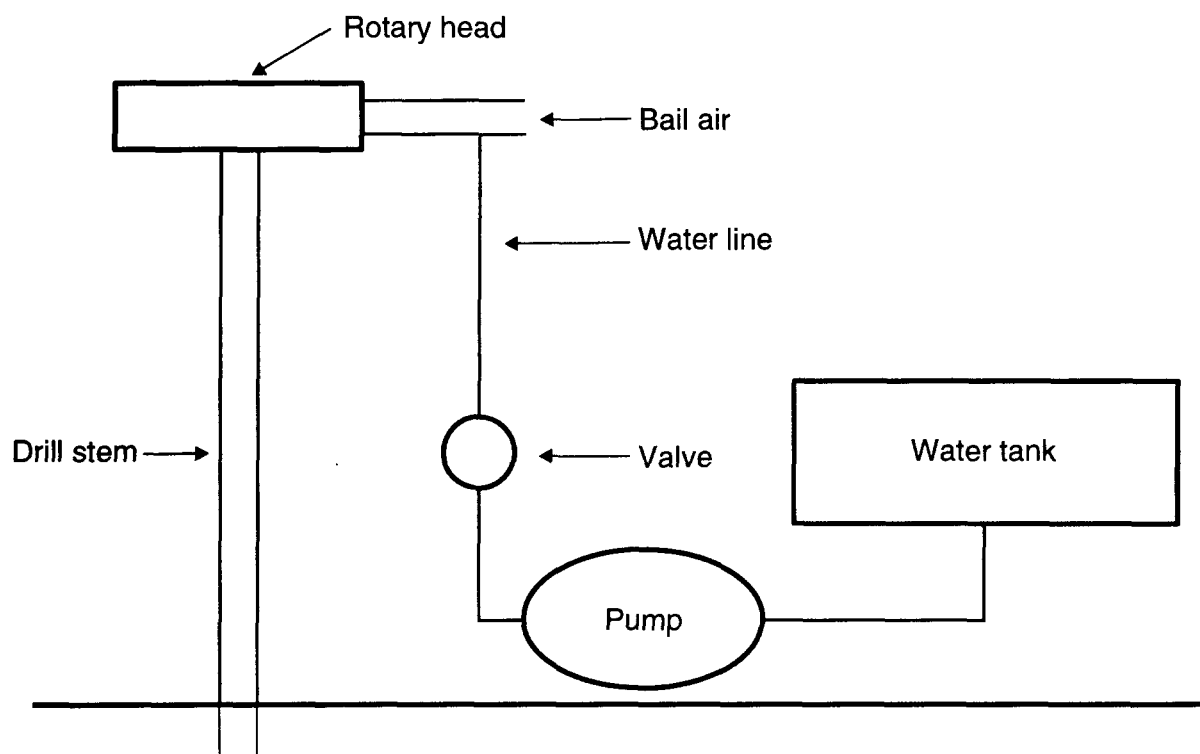


Figure D-1. Wet dust suppression system. (Source: Zimmer and Lueck [1986].)

environment [Volkwein et al. 1979]. Ideally, the air conditioning system should be incorporated into the engine intake system to reduce the number of maintenance items and to insure proper maintenance of both systems [Volkwein et al. 1979].

D.1.4 Improved Control Technology

D.1.4.1 Dust Agglomerator

In a dry dust collection system, the discharge of dust from the dust collector accounts for 40% of the respirable dust emitted [BOM 1989]. The discharged dust can be dispersed by the wind, from impact on the ground, or by equipment driven over dust piles. The dispersed dust poses a potential health hazard not only to the drill crew but also to other miners working in the vicinity. An agglomerator tested by the BOM [1989] offers a solution to these problems. The discharged dust is fed directly into a device that uses gentle water sprays and a spinning motion to coalesce the dust particles into nonrespirable pellets.

D.1.4.2 Water Separation

The moist environment around the drill bit in wet dust suppression has been noted to reduce drill bit life by 50% or more [BOM 1988]. Water separation is a method used to prevent water from reaching the drill bit, thereby prolonging the bit life. In this method, the bail air is guided through one or more sharp turns as it travels down the interior of the drill stem. Because it has a higher inertia than that of air, the water cannot negotiate the turns and thus is separated from the bail air. The dried bail air continues to travel through the drill stem and out of the air orifices of the bit. Under positive pressure, the water is forced out through weep holes into the annular space around the drill stem. Consequently, the drill cuttings are wetted as they are carried upward through this annulus by the bail air below. The BOM [1988] reported that no significant difference in the dust control efficiency was noted between water drilling with and without water separation and that data from one mine showed a greater than 400% increase in average bit life—9,000 ft per bit with water separation versus 1,938 ft per bit without water separation.

D.2 WORK PRACTICES

The selection of a suitable drilling site affects the control efficiency of a dry dust collection system. A drilling site with a flat surface should be selected because this would allow uniform shroud height around the drill. Sometimes the ground surface can be leveled with appropriate equipment.

Where applicable (and coupled with proper maintenance procedures such as replacing worn parts when required), periodic and pre-operational inspections should be made on engineering controls. The following is a checklist of inspection items associated with the different control systems:

- Dry dust collection system
 - Check the integrity of seals and shroud material.

- Check fan belts for proper tension and for wear and tear.
- Check fan blades for wear and tear.
- Check the integrity of dust collector filters.
- Check exhaust ductworks for leakage.
- Wet dust suppression system
 - Check the control valve and the flow meter for proper operation.
 - Check pipe connections for leakage.
- Pressurized cab
 - Check the integrity of seals around the door and windows.
 - Check air filters for dust accumulations.
 - Check fan belts for proper tension and for wear and tear.

When the drill is operating with a totally enclosed cab, the drill crew should stay inside the cab with the door and windows closed as much as practicable. When work must be done outside the cab, the drill crew members should try to position themselves upwind from dust emissions. The drill crew will drag dust with them into the cab as they enter and exit during the drilling operation. Therefore, good housekeeping is necessary to maintain a relatively dust-free environment inside the cab. Vacuuming is effective but may not be practical at the worksite. Whenever possible, wet wiping is preferred over dry sweeping. If dry sweeping is used, care should be exercised to prevent dispersing the settled dust. Cleaning with compressed air should be avoided.

Where a dry dust collection system is used, the shroud must be raised periodically to let the cuttings spill out of the enclosure. The drill crew should be careful to raise the shroud only enough to clear the cuttings; at the same time, they must keep the shroud height low enough to maintain the dust capture efficiency of the system.

D.3 ENGINEERING CONTROLS AND WORK PRACTICES FOR OTHER OCCUPATIONS

For other surface coal miners who are potentially exposed to respirable crystalline silica and respirable coal mine dust, general industrial hygiene control methods should be applied where they are feasible and appropriate to particular operational conditions. Judicious application of engineering controls (e.g., local exhaust ventilation and enclosures) and work practices (e.g., equipment maintenance and housekeeping) is needed for occupations such as bulldozer operator, shotfirer, pan scraper operator, truck driver, and crusher attendant.

Table D-3. Dust suppressants for controlling particulate emissions from unpaved roads*

Category	Description	Examples
Salts	Hygroscopic compounds that extract moisture from the atmosphere and dampen the road surface	Sodium silicates, calcium chloride, magnesium chloride, hydrated lime
Surfactants	Substances capable of reducing the surface tension of the transport liquid, thereby allowing available moisture to wet more dirt particles per unit volume	Soaps, detergents
Adhesives	Compounds that are mixed with native soils to form a new surface	Sodium lignon sulfonate, ammonium lignon sulfonate, calcium lignon sulfonate, Portland cement
Bitumens	Compounds derived from coal or petroleum and mixed with native soils to form a new surface	Asphalt, oils
Films	Polymers that form discrete layers or membranes	Vinyls, fabrics

* Adapted from Rosbury and Zimmer [1983].

D.4 DUST CONTROL ON UNPAVED ROADS

The application of dust suppressants to unpaved roads in surface mines is generally considered useful in reducing dust emissions and improving driver safety by increasing visibility [Rosbury and Zimmer 1983]. The benefits of reduced dust emissions from treated roads could extend to miners working in the vicinity, and especially to truck drivers, in the form of reduced exposures to respirable crystalline silica and respirable coal mine dust. Table D-3 lists the various types of dust suppressants.

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APPENDIX E

INTERPRETATION OF PULMONARY FUNCTION TESTS: SPIROMETRY

For evaluating the results of spirometric examinations, the largest FVC, the largest FEV₁, and the ratio of the largest FEV₁ to the largest FVC (FEV₁/FVC%) from each worker's pulmonary function examination should each be compared with the lower limit of normal (LLN or 5th percentile [ATS 1991]) derived from the reference equations of Knudson et al. [1983] (Tables E-1, E-2, and E-3 for males and Tables E-4, E-5, and E-6 for females) or the most current equivalent. When previous test results for a worker are available, a physician should also determine whether any significant change in FEV₁ has occurred over a period of time. See Appendix G for the criteria for interpreting longitudinal changes in lung function and for a discussion of technical considerations in the use of spirometry for screening and surveillance programs.

REFERENCES CITED IN APPENDIX E

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Table E-1. LLN for FVC for males

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
157	2.89	3.01	3.13	3.25	3.02	2.97	2.92	2.87	2.82	2.77	2.73	2.68	2.38	2.33	2.29	2.25	2.20	2.16	2.12	2.07	2.03	1.98	1.94	1.90	1.85
158	2.94	3.06	3.18	3.29	3.08	3.04	2.99	2.94	2.89	2.84	2.79	2.75	2.44	2.40	2.35	2.31	2.27	2.22	2.18	2.13	2.09	2.05	2.00	1.96	1.92
159	2.99	3.11	3.22	3.34	3.15	3.10	3.06	3.01	2.96	2.91	2.86	2.81	2.50	2.46	2.41	2.37	2.33	2.28	2.24	2.20	2.15	2.11	2.06	2.02	1.98
160	3.04	3.15	3.27	3.39	3.22	3.17	3.12	3.08	3.03	2.98	2.93	2.88	2.56	2.52	2.48	2.43	2.39	2.35	2.30	2.26	2.21	2.17	2.13	2.08	2.04
161	3.08	3.20	3.32	3.44	3.29	3.24	3.19	3.14	3.10	3.05	3.00	2.95	2.63	2.58	2.54	2.50	2.45	2.41	2.36	2.32	2.28	2.23	2.19	2.15	2.10
162	3.13	3.25	3.37	3.48	3.36	3.31	3.26	3.21	3.16	3.12	3.07	3.02	2.69	2.64	2.60	2.56	2.51	2.47	2.43	2.38	2.34	2.29	2.25	2.21	2.16
163	3.18	3.29	3.41	3.53	3.43	3.38	3.33	3.28	3.23	3.18	3.14	3.09	2.75	2.71	2.66	2.62	2.58	2.53	2.49	2.44	2.40	2.36	2.31	2.27	2.23
164	3.22	3.34	3.46	3.58	3.49	3.45	3.40	3.35	3.30	3.25	3.20	3.16	2.81	2.77	2.72	2.68	2.64	2.59	2.55	2.51	2.46	2.42	2.37	2.33	2.29
165	3.27	3.39	3.51	3.62	3.56	3.51	3.47	3.42	3.37	3.32	3.27	3.22	2.87	2.83	2.79	2.74	2.70	2.66	2.61	2.57	2.52	2.48	2.44	2.39	2.35
166	3.32	3.44	3.55	3.67	3.63	3.58	3.53	3.49	3.44	3.39	3.34	3.29	2.94	2.89	2.85	2.80	2.76	2.72	2.67	2.63	2.59	2.54	2.50	2.45	2.41
167	3.36	3.48	3.60	3.72	3.70	3.65	3.60	3.55	3.51	3.46	3.41	3.36	3.00	2.95	2.91	2.87	2.82	2.78	2.74	2.69	2.65	2.60	2.56	2.52	2.47
168	3.41	3.53	3.65	3.77	3.77	3.72	3.67	3.62	3.57	3.53	3.48	3.43	3.06	3.02	2.97	2.93	2.88	2.84	2.80	2.75	2.71	2.67	2.62	2.58	2.53
169	3.46	3.58	3.69	3.81	3.84	3.79	3.74	3.69	3.64	3.59	3.55	3.50	3.12	3.08	3.03	2.99	2.95	2.90	2.86	2.82	2.77	2.73	2.68	2.64	2.60
170	3.51	3.62	3.74	3.86	3.90	3.86	3.81	3.76	3.71	3.66	3.61	3.57	3.18	3.14	3.10	3.05	3.01	2.97	2.92	2.88	2.83	2.79	2.75	2.70	2.66
171	3.55	3.67	3.79	3.91	3.97	3.93	3.88	3.83	3.78	3.73	3.68	3.64	3.25	3.20	3.16	3.11	3.07	3.03	2.98	2.94	2.90	2.85	2.81	2.76	2.72
172	3.60	3.72	3.84	3.95	4.04	3.99	3.95	3.90	3.85	3.80	3.75	3.70	3.31	3.26	3.22	3.18	3.13	3.09	3.05	3.00	2.96	2.91	2.87	2.83	2.78
173	3.65	3.77	3.88	4.00	4.11	4.06	4.01	3.97	3.92	3.87	3.82	3.77	3.37	3.33	3.28	3.24	3.19	3.15	3.11	3.06	3.02	2.98	2.93	2.89	2.84
174	3.69	3.81	3.93	4.05	4.18	4.13	4.08	4.03	3.99	3.94	3.89	3.84	3.43	3.39	3.34	3.30	3.26	3.21	3.17	3.13	3.08	3.04	2.99	2.95	2.91
175	3.74	3.86	3.98	4.10	4.25	4.20	4.15	4.10	4.05	4.01	3.96	3.91	3.49	3.45	3.41	3.36	3.32	3.27	3.23	3.19	3.14	3.10	3.06	3.01	2.97
176	3.79	3.91	4.02	4.14	4.32	4.27	4.22	4.17	4.12	4.07	4.03	3.98	3.56	3.51	3.47	3.42	3.38	3.34	3.29	3.25	3.21	3.16	3.12	3.07	3.03
177	3.84	3.95	4.07	4.19	4.38	4.34	4.29	4.24	4.19	4.14	4.09	4.05	3.62	3.57	3.53	3.49	3.44	3.40	3.35	3.31	3.27	3.22	3.18	3.14	3.09

(Continued)

Table E-1 (Continued). LLN for FVC for males

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
178	3.88	4.00	4.12	4.24	4.45	4.40	4.36	4.31	4.26	4.21	4.16	4.11	3.68	3.64	3.59	3.55	3.50	3.46	3.42	3.37	3.33	3.29	3.24	3.20	3.15
179	3.93	4.05	4.17	4.28	4.52	4.47	4.42	4.38	4.33	4.28	4.23	4.18	3.74	3.70	3.65	3.61	3.57	3.52	3.48	3.44	3.39	3.35	3.30	3.26	3.22
180	3.98	4.09	4.21	4.33	4.59	4.54	4.49	4.44	4.40	4.35	4.30	4.25	3.80	3.76	3.72	3.67	3.63	3.58	3.54	3.50	3.45	3.41	3.37	3.32	3.28
181	4.02	4.14	4.26	4.38	4.66	4.61	4.56	4.51	4.46	4.42	4.37	4.32	3.87	3.82	3.78	3.73	3.69	3.65	3.60	3.56	3.52	3.47	3.43	3.38	3.34
182	4.07	4.19	4.31	4.42	4.73	4.68	4.63	4.58	4.53	4.48	4.44	4.39	3.93	3.88	3.84	3.80	3.75	3.71	3.66	3.62	3.58	3.53	3.49	3.45	3.40
183	4.12	4.24	4.35	4.47	4.79	4.75	4.70	4.65	4.60	4.55	4.50	4.46	3.99	3.95	3.90	3.86	3.81	3.77	3.73	3.68	3.64	3.60	3.55	3.51	3.46
184	4.17	4.28	4.40	4.52	4.86	4.81	4.77	4.72	4.67	4.62	4.57	4.52	4.05	4.01	3.96	3.92	3.88	3.83	3.79	3.74	3.70	3.66	3.61	3.57	3.53
185	4.21	4.33	4.45	4.57	4.93	4.88	4.84	4.79	4.74	4.69	4.64	4.59	4.11	4.07	4.03	3.98	3.94	3.89	3.85	3.81	3.76	3.72	3.68	3.63	3.59
186	4.26	4.38	4.50	4.61	5.00	4.95	4.90	4.86	4.81	4.76	4.71	4.66	4.17	4.13	4.09	4.04	4.00	3.96	3.91	3.87	3.83	3.78	3.74	3.69	3.65
187	4.31	4.42	4.54	4.66	5.07	5.02	4.97	4.92	4.88	4.83	4.78	4.73	4.24	4.19	4.15	4.11	4.06	4.02	3.97	3.93	3.89	3.84	3.80	3.76	3.71
188	4.35	4.47	4.59	4.71	5.14	5.09	5.04	4.99	4.94	4.90	4.85	4.80	4.30	4.26	4.21	4.17	4.12	4.08	4.04	3.99	3.95	3.91	3.86	3.82	3.77
189	4.40	4.52	4.64	4.75	5.21	5.16	5.11	5.06	5.01	4.96	4.92	4.87	4.36	4.32	4.27	4.23	4.19	4.14	4.10	4.05	4.01	3.97	3.92	3.88	3.84
190	4.45	4.57	4.68	4.80	5.27	5.23	5.18	5.13	5.08	5.03	4.98	4.94	4.42	4.38	4.34	4.29	4.25	4.20	4.16	4.12	4.07	4.03	3.99	3.94	3.90
191	4.49	4.61	4.73	4.85	5.34	5.29	5.25	5.20	5.15	5.10	5.05	5.00	4.48	4.44	4.40	4.35	4.31	4.27	4.22	4.18	4.13	4.09	4.05	4.00	3.96
192	4.54	4.66	4.78	4.90	5.41	5.36	5.31	5.27	5.22	5.17	5.12	5.07	4.55	4.50	4.46	4.42	4.37	4.33	4.28	4.24	4.20	4.15	4.11	4.07	4.02
193	4.59	4.71	4.82	4.94	5.48	5.43	5.38	5.33	5.29	5.24	5.19	5.14	4.61	4.56	4.52	4.48	4.43	4.39	4.35	4.30	4.26	4.21	4.17	4.13	4.08

Table E-2. LLN for FEV₁ for males

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
157	2.52	2.62	2.73	2.83	2.52	2.48	2.43	2.38	2.34	2.29	2.25	2.20	2.10	2.06	2.01	1.97	1.92	1.88	1.83	1.79	1.74	1.70	1.65	1.61	1.56
158	2.56	2.67	2.77	2.87	2.58	2.53	2.48	2.44	2.39	2.34	2.30	2.25	2.15	2.11	2.06	2.02	1.97	1.93	1.88	1.84	1.79	1.75	1.70	1.66	1.61
159	2.61	2.71	2.81	2.92	2.63	2.58	2.54	2.49	2.44	2.40	2.35	2.30	2.20	2.16	2.11	2.07	2.02	1.98	1.93	1.89	1.84	1.80	1.75	1.71	1.66
160	2.65	2.75	2.85	2.96	2.68	2.63	2.59	2.54	2.50	2.45	2.40	2.36	2.26	2.21	2.17	2.12	2.08	2.03	1.98	1.94	1.89	1.85	1.80	1.76	1.71
161	2.69	2.79	2.90	3.00	2.73	2.69	2.64	2.59	2.55	2.50	2.46	2.41	2.31	2.26	2.22	2.17	2.13	2.08	2.04	1.99	1.95	1.90	1.86	1.81	1.77
162	2.73	2.84	2.94	3.04	2.79	2.74	2.69	2.65	2.60	2.55	2.51	2.46	2.36	2.31	2.27	2.22	2.18	2.13	2.09	2.04	2.00	1.95	1.91	1.86	1.82
163	2.77	2.88	2.98	3.08	2.84	2.79	2.75	2.70	2.65	2.61	2.56	2.52	2.41	2.36	2.32	2.27	2.23	2.18	2.14	2.09	2.05	2.00	1.96	1.91	1.87
164	2.82	2.92	3.02	3.13	2.89	2.84	2.80	2.75	2.71	2.66	2.61	2.57	2.46	2.42	2.37	2.33	2.28	2.24	2.19	2.15	2.10	2.06	2.01	1.96	1.92
165	2.86	2.96	3.07	3.17	2.94	2.90	2.85	2.81	2.76	2.71	2.67	2.62	2.51	2.47	2.42	2.38	2.33	2.29	2.24	2.20	2.15	2.11	2.06	2.02	1.97
166	2.90	3.00	3.11	3.21	3.00	2.95	2.90	2.86	2.81	2.77	2.72	2.67	2.56	2.52	2.47	2.43	2.38	2.34	2.29	2.25	2.20	2.16	2.11	2.07	2.02
167	2.94	3.05	3.15	3.25	3.05	3.00	2.96	2.91	2.86	2.82	2.77	2.73	2.61	2.57	2.52	2.48	2.43	2.39	2.34	2.30	2.25	2.21	2.16	2.12	2.07
168	2.99	3.09	3.19	3.29	3.10	3.06	3.01	2.96	2.92	2.87	2.82	2.78	2.67	2.62	2.58	2.53	2.49	2.44	2.40	2.35	2.31	2.26	2.22	2.17	2.13
169	3.03	3.13	3.23	3.34	3.15	3.11	3.06	3.02	2.97	2.92	2.88	2.83	2.72	2.67	2.63	2.58	2.54	2.49	2.45	2.40	2.36	2.31	2.27	2.22	2.18
170	3.07	3.17	3.28	3.38	3.21	3.16	3.11	3.07	3.02	2.98	2.93	2.88	2.77	2.72	2.68	2.63	2.59	2.54	2.50	2.45	2.41	2.36	2.32	2.27	2.23
171	3.11	3.21	3.32	3.42	3.26	3.21	3.17	3.12	3.07	3.03	2.98	2.94	2.82	2.78	2.73	2.68	2.64	2.59	2.55	2.50	2.46	2.41	2.37	2.32	2.28
172	3.15	3.26	3.36	3.46	3.31	3.27	3.22	3.17	3.13	3.08	3.03	2.99	2.87	2.83	2.78	2.74	2.69	2.65	2.60	2.56	2.51	2.47	2.42	2.38	2.33
173	3.20	3.30	3.40	3.51	3.36	3.32	3.27	3.23	3.18	3.13	3.09	3.04	2.92	2.88	2.83	2.79	2.74	2.70	2.65	2.61	2.56	2.52	2.47	2.43	2.38
174	3.24	3.34	3.44	3.55	3.42	3.37	3.32	3.28	3.23	3.19	3.14	3.09	2.97	2.93	2.88	2.84	2.79	2.75	2.70	2.66	2.61	2.57	2.52	2.48	2.43
175	3.28	3.38	3.49	3.59	3.47	3.42	3.38	3.33	3.28	3.24	3.19	3.15	3.03	2.98	2.94	2.89	2.85	2.80	2.76	2.71	2.66	2.62	2.57	2.53	2.48
176	3.32	3.43	3.53	3.63	3.52	3.48	3.43	3.38	3.34	3.29	3.25	3.20	3.08	3.03	2.99	2.94	2.90	2.85	2.81	2.76	2.72	2.67	2.63	2.58	2.54
177	3.36	3.47	3.57	3.67	3.57	3.53	3.48	3.44	3.39	3.34	3.30	3.25	3.13	3.08	3.04	2.99	2.95	2.90	2.86	2.81	2.77	2.72	2.68	2.63	2.59

(Continued)

Table E-2 (Continued). LLN for FEV₁ for males

Height (cm)	Age															
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47
178	3.41	3.51	3.61	3.72	3.63	3.58	3.54	3.49	3.44	3.40	3.35	3.30	3.18	3.13	3.09	3.04
179	3.45	3.55	3.66	3.76	3.68	3.63	3.59	3.54	3.50	3.45	3.40	3.36	3.23	3.19	3.14	3.10
180	3.49	3.59	3.70	3.80	3.73	3.69	3.64	3.59	3.55	3.50	3.46	3.41	3.28	3.24	3.19	3.15
181	3.53	3.64	3.74	3.84	3.79	3.74	3.69	3.65	3.60	3.55	3.51	3.46	3.33	3.29	3.24	3.20
182	3.58	3.68	3.78	3.88	3.84	3.79	3.75	3.70	3.65	3.61	3.56	3.51	3.38	3.34	3.29	3.25
183	3.62	3.72	3.82	3.93	3.89	3.84	3.80	3.75	3.71	3.66	3.61	3.57	3.44	3.39	3.35	3.30
184	3.66	3.76	3.87	3.97	3.94	3.90	3.85	3.80	3.76	3.71	3.67	3.62	3.49	3.44	3.40	3.35
185	3.70	3.80	3.91	4.01	4.00	3.95	3.90	3.86	3.81	3.76	3.72	3.67	3.54	3.49	3.45	3.40
186	3.74	3.85	3.95	4.05	4.05	4.00	3.96	3.91	3.86	3.82	3.77	3.72	3.59	3.55	3.50	3.46
187	3.79	3.89	3.99	4.10	4.10	4.05	4.01	3.96	3.92	3.87	3.82	3.78	3.64	3.60	3.55	3.51
188	3.83	3.93	4.03	4.14	4.15	4.11	4.06	4.01	3.97	3.92	3.88	3.83	3.69	3.65	3.60	3.56
189	3.87	3.97	4.08	4.18	4.21	4.16	4.11	4.07	4.02	3.98	3.93	3.88	3.74	3.70	3.65	3.61
190	3.91	4.02	4.12	4.22	4.26	4.21	4.17	4.12	4.07	4.03	3.98	3.94	3.80	3.75	3.71	3.66
191	3.95	4.06	4.16	4.26	4.31	4.27	4.22	4.17	4.13	4.08	4.03	3.99	3.85	3.80	3.76	3.71
192	4.00	4.10	4.20	4.31	4.36	4.32	4.27	4.23	4.18	4.13	4.09	4.04	3.90	3.85	3.81	3.76
193	4.04	4.14	4.25	4.35	4.42	4.37	4.32	4.28	4.23	4.19	4.14	4.09	3.95	3.90	3.86	3.81

Table E-3. LLN for FEV₁/FVC % for males

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
157	74.5	74.5	74.5	74.5	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
158	74.4	74.4	74.4	74.4	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
159	74.3	74.3	74.3	74.3	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
160	74.3	74.3	74.3	74.3	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
161	74.2	74.2	74.2	74.2	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
162	74.1	74.1	74.1	74.1	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
163	74.1	74.1	74.1	74.1	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
164	74.0	74.0	74.0	74.0	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
165	73.9	73.9	73.9	73.9	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
166	73.9	73.9	73.9	73.9	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
167	73.8	73.8	73.8	73.8	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
168	73.7	73.7	73.7	73.7	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
169	73.6	73.6	73.6	73.6	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
170	73.6	73.6	73.6	73.6	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
171	73.5	73.5	73.5	73.5	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
172	73.4	73.4	73.4	73.4	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
173	73.4	73.4	73.4	73.4	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
174	73.3	73.3	73.3	73.3	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
175	73.2	73.2	73.2	73.2	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
176	73.2	73.2	73.2	73.2	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
177	73.1	73.1	73.1	73.1	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3

(Continued)

Table E-3 (Continued). LLN for FEV₁/FVC % for males

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
178	73.0	73.0	73.0	73.0	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
179	73.0	73.0	73.0	73.0	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
180	72.9	72.9	72.9	72.9	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
181	72.8	72.8	72.8	72.8	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
182	72.7	72.7	72.7	72.7	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
183	72.7	72.7	72.7	72.7	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
184	72.6	72.6	72.6	72.6	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
185	72.5	72.5	72.5	72.5	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
186	72.5	72.5	72.5	72.5	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
187	72.4	72.4	72.4	72.4	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
188	72.3	72.3	72.3	72.3	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
189	72.3	72.3	72.3	72.3	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
190	72.2	72.2	72.2	72.2	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
191	72.1	72.1	72.1	72.1	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
192	72.1	72.1	72.1	72.1	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3
193	72.0	72.0	72.0	72.0	73.0	72.8	72.6	72.5	72.3	72.1	71.9	71.7	71.5	71.4	71.2	71.0	70.8	70.6	70.4	70.3	70.1	69.9	69.7	69.5	69.3

Table E-4. LLN for FVC for females

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
148	2.17	2.27	2.32	2.29	2.27	2.24	2.21	2.19	2.16	2.14	2.11	2.08	2.01	1.99	1.96	1.94	1.91	1.89	1.86	1.84	1.81	1.78	1.76	1.73	1.71
149	2.20	2.30	2.35	2.33	2.30	2.27	2.25	2.22	2.20	2.17	2.14	2.12	2.05	2.02	2.00	1.97	1.94	1.92	1.89	1.87	1.84	1.82	1.79	1.77	1.74
150	2.23	2.33	2.39	2.36	2.33	2.31	2.28	2.26	2.23	2.20	2.18	2.15	2.08	2.05	2.03	2.00	1.98	1.95	1.93	1.90	1.88	1.85	1.83	1.80	1.77
151	2.26	2.36	2.42	2.40	2.37	2.34	2.32	2.29	2.27	2.24	2.21	2.19	2.11	2.09	2.06	2.04	2.01	1.99	1.96	1.94	1.91	1.88	1.86	1.83	1.81
152	2.29	2.40	2.46	2.43	2.40	2.38	2.35	2.33	2.30	2.27	2.25	2.22	2.15	2.12	2.10	2.07	2.04	2.02	1.99	1.97	1.94	1.92	1.89	1.87	1.84
153	2.32	2.43	2.49	2.46	2.44	2.41	2.39	2.36	2.33	2.31	2.28	2.26	2.18	2.15	2.13	2.10	2.08	2.05	2.03	2.00	1.98	1.95	1.93	1.90	1.88
154	2.35	2.46	2.52	2.50	2.47	2.45	2.42	2.39	2.37	2.34	2.32	2.29	2.21	2.19	2.16	2.14	2.11	2.09	2.06	2.04	2.01	1.98	1.96	1.93	1.91
155	2.38	2.49	2.56	2.53	2.51	2.48	2.45	2.43	2.40	2.38	2.35	2.32	2.25	2.22	2.20	2.17	2.15	2.12	2.09	2.07	2.04	2.02	1.99	1.97	1.94
156	2.41	2.52	2.59	2.57	2.54	2.51	2.49	2.46	2.44	2.41	2.38	2.36	2.28	2.25	2.23	2.20	2.18	2.15	2.13	2.10	2.08	2.05	2.03	2.00	1.98
157	2.45	2.55	2.63	2.60	2.57	2.55	2.52	2.50	2.47	2.44	2.42	2.39	2.31	2.29	2.26	2.24	2.21	2.19	2.16	2.14	2.11	2.08	2.06	2.03	2.01
158	2.48	2.58	2.66	2.63	2.61	2.58	2.56	2.53	2.50	2.48	2.45	2.43	2.35	2.32	2.30	2.27	2.25	2.22	2.19	2.17	2.14	2.12	2.09	2.07	2.04
159	2.51	2.61	2.69	2.67	2.64	2.62	2.59	2.56	2.54	2.51	2.49	2.46	2.38	2.35	2.33	2.30	2.28	2.25	2.23	2.20	2.18	2.15	2.13	2.10	2.08
160	2.54	2.64	2.73	2.70	2.68	2.65	2.62	2.60	2.57	2.55	2.52	2.49	2.41	2.39	2.36	2.34	2.31	2.29	2.26	2.24	2.21	2.18	2.16	2.13	2.11
161	2.57	2.68	2.76	2.74	2.71	2.68	2.66	2.63	2.61	2.58	2.55	2.53	2.45	2.42	2.40	2.37	2.35	2.32	2.29	2.27	2.24	2.22	2.19	2.17	2.14
162	2.60	2.71	2.80	2.77	2.74	2.72	2.69	2.67	2.64	2.61	2.59	2.56	2.48	2.46	2.43	2.40	2.38	2.35	2.33	2.30	2.28	2.25	2.23	2.20	2.18
163	2.63	2.74	2.83	2.80	2.78	2.75	2.73	2.70	2.67	2.65	2.62	2.60	2.51	2.49	2.46	2.44	2.41	2.39	2.36	2.34	2.31	2.29	2.26	2.23	2.21
164	2.66	2.77	2.86	2.84	2.81	2.79	2.76	2.73	2.71	2.68	2.66	2.63	2.55	2.52	2.50	2.47	2.45	2.42	2.39	2.37	2.34	2.32	2.29	2.27	2.24
165	2.70	2.80	2.90	2.87	2.85	2.82	2.80	2.77	2.74	2.72	2.69	2.67	2.58	2.56	2.53	2.50	2.48	2.45	2.43	2.40	2.38	2.35	2.33	2.30	2.28
166	2.73	2.83	2.93	2.91	2.88	2.86	2.83	2.80	2.78	2.75	2.73	2.70	2.61	2.59	2.56	2.54	2.51	2.49	2.46	2.44	2.41	2.39	2.36	2.33	2.31
167	2.76	2.86	2.97	2.94	2.92	2.89	2.86	2.84	2.81	2.79	2.76	2.73	2.65	2.62	2.60	2.57	2.55	2.52	2.49	2.47	2.44	2.42	2.39	2.37	2.34
168	2.79	2.89	3.00	2.98	2.95	2.92	2.90	2.87	2.85	2.82	2.79	2.77	2.68	2.66	2.63	2.60	2.58	2.55	2.53	2.50	2.48	2.45	2.43	2.40	2.38

(Continued)

Table E-4 (Continued). LLN for FVC for females

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
169	2.82	2.92	3.04	3.01	2.98	2.96	2.93	2.91	2.88	2.85	2.83	2.80	2.71	2.69	2.66	2.64	2.61	2.59	2.56	2.54	2.51	2.49	2.46	2.43	2.41
170	2.85	2.96	3.07	3.04	3.02	2.99	2.97	2.94	2.91	2.89	2.86	2.84	2.75	2.72	2.70	2.67	2.65	2.62	2.60	2.56	2.54	2.52	2.49	2.47	2.44
171	2.88	2.99	3.10	3.08	3.05	3.03	3.00	2.97	2.95	2.92	2.90	2.87	2.78	2.76	2.73	2.70	2.68	2.65	2.63	2.60	2.58	2.55	2.53	2.50	2.48
172	2.91	3.02	3.14	3.11	3.09	3.06	3.03	3.01	2.98	2.96	2.93	2.90	2.81	2.79	2.76	2.74	2.71	2.69	2.66	2.64	2.61	2.59	2.56	2.53	2.51
173	2.94	3.05	3.17	3.15	3.12	3.09	3.07	3.04	3.02	2.99	2.96	2.94	2.85	2.82	2.80	2.77	2.75	2.72	2.70	2.67	2.64	2.62	2.59	2.57	2.54
174	2.98	3.08	3.21	3.18	3.15	3.13	3.10	3.08	3.05	3.02	3.00	2.97	2.88	2.86	2.83	2.80	2.78	2.75	2.73	2.70	2.68	2.65	2.63	2.60	2.58
175	3.01	3.11	3.24	3.21	3.19	3.16	3.14	3.11	3.08	3.06	3.03	3.01	2.91	2.89	2.86	2.84	2.81	2.79	2.76	2.74	2.71	2.69	2.66	2.63	2.61
176	3.04	3.14	3.27	3.25	3.22	3.20	3.17	3.14	3.12	3.09	3.07	3.04	2.95	2.92	2.90	2.87	2.85	2.82	2.80	2.77	2.74	2.72	2.69	2.67	2.64
177	3.07	3.17	3.31	3.28	3.26	3.23	3.20	3.18	3.15	3.13	3.10	3.07	2.98	2.96	2.93	2.91	2.88	2.85	2.83	2.80	2.78	2.75	2.73	2.70	2.68
178	3.10	3.21	3.34	3.32	3.29	3.26	3.24	3.21	3.19	3.16	3.13	3.11	3.01	2.99	2.96	2.94	2.91	2.89	2.86	2.84	2.81	2.79	2.76	2.74	2.71
179	3.13	3.24	3.38	3.35	3.33	3.30	3.27	3.25	3.22	3.20	3.17	3.14	3.05	3.02	3.00	2.97	2.95	2.92	2.90	2.87	2.84	2.82	2.79	2.77	2.74
180	3.16	3.27	3.41	3.39	3.36	3.33	3.31	3.28	3.26	3.23	3.20	3.18	3.08	3.06	3.03	3.01	2.98	2.95	2.93	2.90	2.88	2.85	2.83	2.80	2.78
181	3.19	3.30	3.45	3.42	3.39	3.37	3.34	3.32	3.29	3.26	3.24	3.21	3.11	3.09	3.06	3.04	3.01	2.99	2.96	2.94	2.91	2.89	2.86	2.84	2.81
182	3.23	3.33	3.48	3.45	3.43	3.40	3.38	3.35	3.32	3.30	3.27	3.25	3.15	3.12	3.10	3.07	3.05	3.02	3.00	2.97	2.94	2.92	2.89	2.87	2.84
183	3.26	3.36	3.51	3.49	3.46	3.44	3.41	3.38	3.36	3.33	3.31	3.28	3.18	3.16	3.13	3.11	3.08	3.05	3.03	3.00	2.98	2.95	2.93	2.90	2.88
184	3.29	3.39	3.55	3.52	3.50	3.47	3.44	3.42	3.39	3.37	3.34	3.31	3.22	3.19	3.16	3.14	3.11	3.09	3.06	3.04	3.01	2.99	2.96	2.94	2.91

Table E-5. LLN for FEV₁ for females

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
148	2.13	2.25	2.09	2.06	2.03	2.00	1.97	1.95	1.92	1.89	1.86	1.83	1.80	1.77	1.74	1.71	1.68	1.65	1.62	1.59	1.56	1.53	1.50	1.47	1.44
149	2.16	2.27	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.91	1.88	1.85	1.82	1.79	1.76	1.73	1.70	1.68	1.65	1.62	1.59	1.56	1.53	1.50	1.47
150	2.19	2.30	2.15	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.91	1.88	1.85	1.82	1.79	1.76	1.73	1.70	1.67	1.64	1.61	1.58	1.55	1.52	1.49
151	2.22	2.33	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96	1.93	1.90	1.87	1.85	1.82	1.79	1.76	1.73	1.70	1.67	1.64	1.61	1.58	1.55	1.52
152	2.25	2.36	2.20	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96	1.93	1.90	1.87	1.84	1.81	1.78	1.75	1.72	1.69	1.66	1.63	1.60	1.58	1.55
153	2.28	2.39	2.22	2.19	2.16	2.13	2.10	2.07	2.05	2.02	1.99	1.96	1.93	1.90	1.87	1.84	1.81	1.78	1.75	1.72	1.69	1.66	1.63	1.60	1.57
154	2.30	2.42	2.25	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.01	1.98	1.95	1.92	1.89	1.86	1.83	1.80	1.77	1.75	1.72	1.69	1.66	1.63	1.60
155	2.33	2.45	2.27	2.24	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.01	1.98	1.95	1.92	1.89	1.86	1.83	1.80	1.77	1.74	1.71	1.68	1.65	1.62
156	2.36	2.48	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.92	1.89	1.86	1.83	1.80	1.77	1.74	1.71	1.68	1.65
157	2.39	2.50	2.33	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.91	1.88	1.85	1.82	1.79	1.76	1.73	1.70	1.67
158	2.42	2.53	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.91	1.88	1.85	1.82	1.79	1.76	1.73	1.70
159	2.45	2.56	2.38	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96	1.93	1.90	1.87	1.84	1.82	1.79	1.76	1.73
160	2.48	2.59	2.40	2.37	2.34	2.31	2.29	2.26	2.23	2.20	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96	1.93	1.90	1.87	1.84	1.81	1.78	1.75
161	2.51	2.62	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.02	1.99	1.96	1.93	1.90	1.87	1.84	1.81	1.78
162	2.53	2.65	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.01	1.98	1.95	1.92	1.89	1.86	1.83	1.80
163	2.56	2.68	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27	2.24	2.21	2.19	2.16	2.13	2.10	2.07	2.04	2.01	1.98	1.95	1.92	1.89	1.86	1.83
164	2.59	2.70	2.51	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.92	1.89	1.86
165	2.62	2.73	2.53	2.50	2.47	2.44	2.41	2.38	2.36	2.33	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09	2.06	2.03	2.00	1.97	1.94	1.91	1.88
166	2.65	2.76	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14	2.11	2.09	2.06	2.03	2.00	1.97	1.94	1.91
167	2.68	2.79	2.58	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96	1.93
168	2.71	2.82	2.61	2.58	2.55	2.52	2.49	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.26	2.23	2.20	2.17	2.14	2.11	2.08	2.05	2.02	1.99	1.96

(Continued)

Table E-5 (Continued). LLN for FEV₁ for females

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
169	2.73	2.85	2.64	2.61	2.58	2.55	2.52	2.49	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.01	1.99
170	2.76	2.88	2.66	2.63	2.60	2.57	2.54	2.51	2.48	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22	2.19	2.16	2.13	2.10	2.07	2.04	2.01
171	2.79	2.91	2.69	2.66	2.63	2.60	2.57	2.54	2.51	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27	2.24	2.21	3.18	2.16	2.13	2.10	2.07	2.04
172	2.82	2.93	2.71	2.68	2.65	2.63	2.60	2.57	2.54	2.51	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09	2.06
173	2.85	2.96	2.74	2.71	2.68	2.65	2.62	2.59	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.36	2.33	2.30	2.27	2.24	2.21	2.18	2.15	2.12	2.09
174	2.88	2.99	2.77	2.74	2.71	2.68	2.65	2.62	2.59	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14	2.11
175	2.91	3.02	2.79	2.76	2.73	2.70	2.67	2.64	2.61	2.58	2.55	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.32	2.29	2.26	2.23	2.20	2.17	2.14
176	2.94	3.05	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.61	2.58	2.55	2.52	2.49	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.26	2.23	2.20	2.17
177	2.96	3.08	2.84	2.81	2.78	2.75	2.72	2.70	2.67	2.64	2.61	2.58	2.55	2.52	2.49	2.46	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22	2.19
178	2.99	3.11	2.87	2.84	2.81	2.78	2.75	2.72	2.69	2.66	2.63	2.60	2.57	2.54	2.51	2.48	2.45	2.43	2.40	2.37	2.34	2.31	2.28	2.25	2.22
179	3.02	3.14	2.90	2.87	2.84	2.81	2.78	2.75	2.72	2.69	2.66	2.63	2.60	2.57	2.54	2.51	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27	2.24
180	3.05	3.16	2.92	2.89	2.86	2.83	2.80	2.77	2.74	2.71	2.68	2.65	2.62	2.60	2.57	2.54	2.51	2.48	2.45	2.42	2.39	2.36	2.33	2.30	2.27
181	3.08	3.19	2.95	2.92	2.89	2.86	2.83	2.80	2.77	2.74	2.71	2.68	2.65	2.62	2.59	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.33	2.30
182	3.11	3.22	2.97	2.94	2.91	2.88	2.85	2.82	2.80	2.77	2.74	2.71	2.68	2.65	2.62	2.59	2.56	2.53	2.50	2.47	2.44	2.41	2.38	2.35	2.32
183	3.14	3.25	3.00	2.97	2.94	2.91	2.88	2.85	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.61	2.58	2.55	2.52	2.50	2.47	2.44	2.41	2.38	2.35
184	3.17	3.28	3.02	2.99	2.97	2.94	2.91	2.88	2.85	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.61	2.58	2.55	2.52	2.49	2.46	2.43	2.40	2.37

Table E-6. LLN for FEV₁/FVC % for females

Height (cm)	Age																								
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
148	74.8	75.9	77.5	77.2	76.9	76.5	76.2	75.9	75.6	75.2	74.9	74.6	74.2	73.9	73.6	73.3	72.9	72.6	72.3	72.0	71.6	71.3	71.0	70.7	70.3
149	74.7	75.8	77.3	77.0	76.7	76.4	76.0	75.7	75.4	75.1	74.7	74.4	74.1	73.8	73.4	73.1	72.8	72.5	72.1	71.8	71.5	71.2	70.8	70.5	70.2
150	74.5	75.6	77.2	76.9	76.5	76.2	75.9	75.6	75.2	74.9	74.6	74.3	73.9	73.6	73.3	73.0	72.6	72.3	72.0	71.7	71.3	71.0	70.7	70.3	70.0
151	74.4	75.5	77.0	76.7	76.4	76.1	75.7	75.4	75.1	74.7	74.4	74.1	73.8	73.4	73.1	72.8	72.5	72.1	71.8	71.5	71.2	70.8	70.5	70.2	69.9
152	74.2	75.3	76.9	76.5	76.2	75.9	75.6	75.2	74.9	74.6	74.3	73.9	73.6	73.3	73.0	72.6	72.3	72.0	71.7	71.3	71.0	70.7	70.4	70.0	69.7
153	74.1	75.1	76.7	76.4	76.1	75.7	75.4	75.1	74.8	74.4	74.1	73.8	73.5	73.1	72.8	72.5	72.2	71.8	71.5	71.2	70.8	70.5	70.2	69.9	69.5
154	73.9	75.0	76.6	76.2	75.9	75.6	75.2	74.9	74.6	74.3	73.9	73.6	73.3	73.0	72.6	72.3	72.0	71.7	71.3	71.0	70.7	70.4	70.0	69.7	69.4
155	73.8	74.8	76.4	76.1	75.7	75.4	75.1	74.8	74.4	74.1	73.8	73.5	73.1	72.8	72.5	72.2	71.8	71.5	71.2	70.9	70.5	70.2	69.9	69.6	69.2
156	73.6	74.7	76.2	75.9	75.6	75.3	74.9	74.6	74.3	74.0	73.6	73.3	73.0	72.7	72.3	72.0	71.7	71.3	71.0	70.7	70.4	70.0	69.7	69.4	69.1
157	73.5	74.5	76.1	75.7	75.4	75.1	74.8	74.4	74.1	73.8	73.5	73.1	72.8	72.5	72.2	71.8	71.5	71.2	70.9	70.5	70.2	69.9	69.6	69.2	68.9
158	73.3	74.4	75.9	75.6	75.3	74.9	74.6	74.3	74.0	73.6	73.3	73.0	72.7	72.3	72.0	71.7	71.4	71.0	70.7	70.4	70.1	69.7	69.4	69.1	68.7
159	73.2	74.2	75.8	75.4	75.1	74.8	74.5	74.1	73.8	73.5	73.2	72.8	72.5	72.2	71.8	71.5	71.2	70.9	70.5	70.2	69.9	69.6	69.2	68.9	68.6
160	73.0	74.1	75.6	75.3	74.9	74.6	74.3	74.0	73.6	73.3	73.0	72.7	72.3	72.0	71.7	71.4	71.0	70.7	70.4	70.1	69.7	69.4	69.1	68.8	68.4
161	72.8	73.9	75.4	75.1	74.8	74.5	74.1	73.8	73.5	73.2	72.8	72.5	72.2	71.9	71.5	71.2	70.9	70.6	70.2	69.9	69.6	69.2	68.9	68.6	68.3
162	72.7	73.8	75.3	75.0	74.6	74.3	74.0	73.7	73.3	73.0	72.7	72.3	72.0	71.7	71.4	71.0	70.7	70.4	70.1	69.7	69.4	69.1	68.8	68.4	68.1
163	72.5	73.6	75.1	74.8	74.5	74.1	73.8	73.5	73.2	72.8	72.5	72.2	71.9	71.5	71.2	70.9	70.6	70.2	69.9	69.6	69.3	68.9	68.6	68.3	68.0
164	72.4	73.5	75.0	74.6	74.3	74.0	73.7	73.3	73.0	72.7	72.4	72.0	71.7	71.4	71.1	70.7	70.4	70.1	69.7	69.4	69.1	68.8	68.4	68.1	67.8
165	72.2	73.3	74.8	74.5	74.2	73.8	73.5	73.2	72.8	72.5	72.2	71.9	71.5	71.2	70.9	70.6	70.2	69.9	69.6	69.3	68.9	68.6	68.3	68.0	67.6
166	72.1	73.1	74.6	74.3	74.0	73.7	73.3	73.0	72.7	72.4	72.0	71.7	71.4	71.1	70.7	70.4	70.1	69.8	69.4	69.1	68.8	68.5	68.1	67.8	67.5
167	71.9	73.0	74.5	74.2	73.8	73.5	73.2	72.9	72.5	72.2	71.9	71.6	71.2	70.9	70.6	70.2	69.9	69.6	69.3	68.9	68.6	68.3	68.0	67.6	67.3
168	71.8	72.8	74.3	74.0	73.7	73.3	73.0	72.7	72.4	72.0	71.7	71.4	71.1	70.7	70.4	70.1	69.8	69.4	69.1	68.8	68.5	68.1	67.8	67.5	67.2

(Continued)

Table E-6 (Continued). LLN for FEV₁/FVC % for females

Height (cm)	Age															
	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47
169	71.6	72.7	74.2	73.8	73.5	73.2	72.9	72.5	72.2	71.9	71.6	71.2	70.9	70.6	70.3	69.9
170	71.5	72.5	74.0	73.7	73.4	73.0	72.7	72.4	72.1	71.7	71.4	71.1	70.7	70.4	70.1	69.8
171	71.3	72.4	73.8	73.5	73.2	72.9	72.5	72.2	71.9	71.6	71.2	70.9	70.6	70.3	69.9	69.6
172	71.2	72.2	73.7	73.4	73.0	72.7	72.4	72.1	71.7	71.4	71.1	70.8	70.4	70.1	69.8	69.5
173	71.0	72.1	73.5	73.2	72.9	72.6	72.2	71.9	71.6	71.2	70.9	70.6	70.3	69.9	69.6	69.3
174	70.8	71.9	73.4	73.0	72.7	72.4	72.1	71.7	71.4	71.1	70.8	70.4	70.1	69.8	69.5	69.1
175	70.7	71.8	73.2	72.9	72.6	72.2	71.9	71.6	71.3	70.9	70.6	70.3	70.0	69.6	69.3	69.0
176	70.5	71.6	73.1	72.7	72.4	72.1	71.7	71.4	71.1	70.8	70.4	70.1	69.8	69.5	69.1	68.8
177	70.4	71.5	72.9	72.6	72.2	71.9	71.6	71.3	70.9	70.6	70.3	70.0	69.6	69.3	69.0	68.7
178	70.2	71.3	72.7	72.4	72.1	71.8	71.4	71.1	70.8	70.5	70.1	69.8	69.5	69.2	68.8	68.5
179	70.1	71.2	72.6	72.2	71.9	71.6	71.3	70.9	70.6	70.3	70.0	69.6	69.3	69.0	68.7	68.3
180	69.9	71.0	72.4	72.1	71.8	71.4	71.1	70.8	70.5	70.1	69.8	69.5	69.2	68.8	68.5	68.2
181	69.8	70.8	72.3	71.9	71.6	71.3	71.0	70.6	70.3	70.0	69.7	69.3	69.0	68.7	68.3	68.0
182	69.6	70.7	72.1	71.8	71.4	71.1	70.8	70.5	70.1	69.8	69.5	69.2	68.8	68.5	68.2	67.9
183	69.5	70.5	71.9	71.6	71.3	71.0	70.6	70.3	70.0	69.7	69.3	69.0	68.7	68.4	68.0	67.7
184	69.3	70.4	71.8	71.5	71.1	70.8	70.5	70.2	69.8	69.5	69.2	68.8	68.5	68.2	67.9	67.5